What kind of competition food vs fuel in sweet sorghum ?

S. Braconnier, G. Trouche, S. Gutjahr, D. Pot, D. Luquet

cirad
AGRICULTURAL RESEARCH
FOR DEVELOPMENT

Working together for tomorrow's agriculture

(www.cirad.fr)
(umr-agap.cirad.fr)

CIRAD worldwide

700 staff members based outside metropolitan France

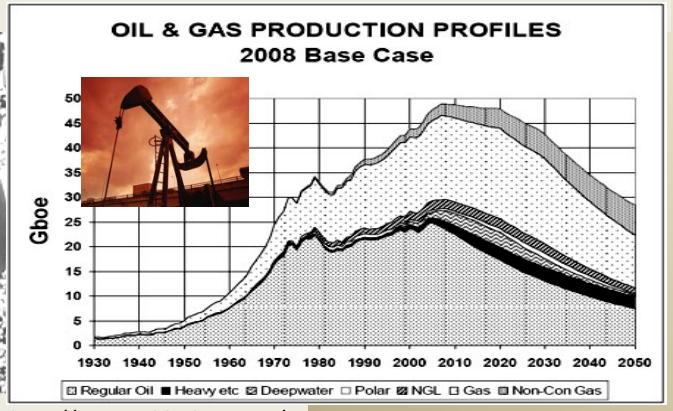
A scientific hub in Montpellier

Project "Sweet sorghum: an alternative energy crop (SWEETFUEL)

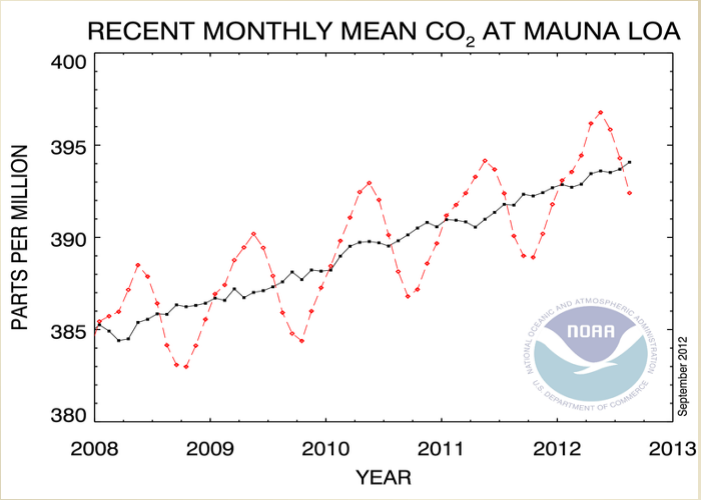
Coordinator:	**CIRAD**
Budget :	**Total = ~ 5 million € for a contribution from the EC ~ 3 million €**
Duration	**= 5 years (2009-2013)**
10 partners:	**CIRAD, ICRISAT, EMBRAPA, KWS, IFEU, UniBO, UCSC, ARC-GCI, UANL, WIP**
Objective:	**Development of ethanol production from sorghum in temperate and semi arid tropics through development of new varieties adapted to the target environments.**
Web site	**www.sweetfuel-project.eu**

Context

Global oil production is rapidly approaching its peak

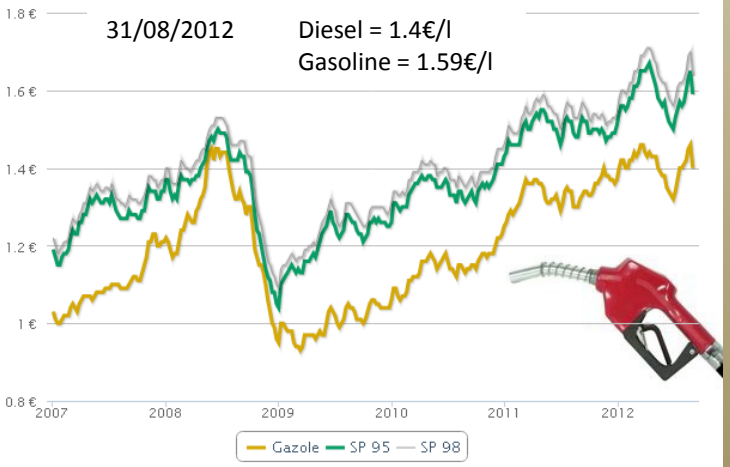


http://www.oildecline.com/



CO_2 atmospheric concentration in Aug. 2012 = **392.41 ppm**
http://www.esrl.noaa.gov

Evolution of price at the gas station



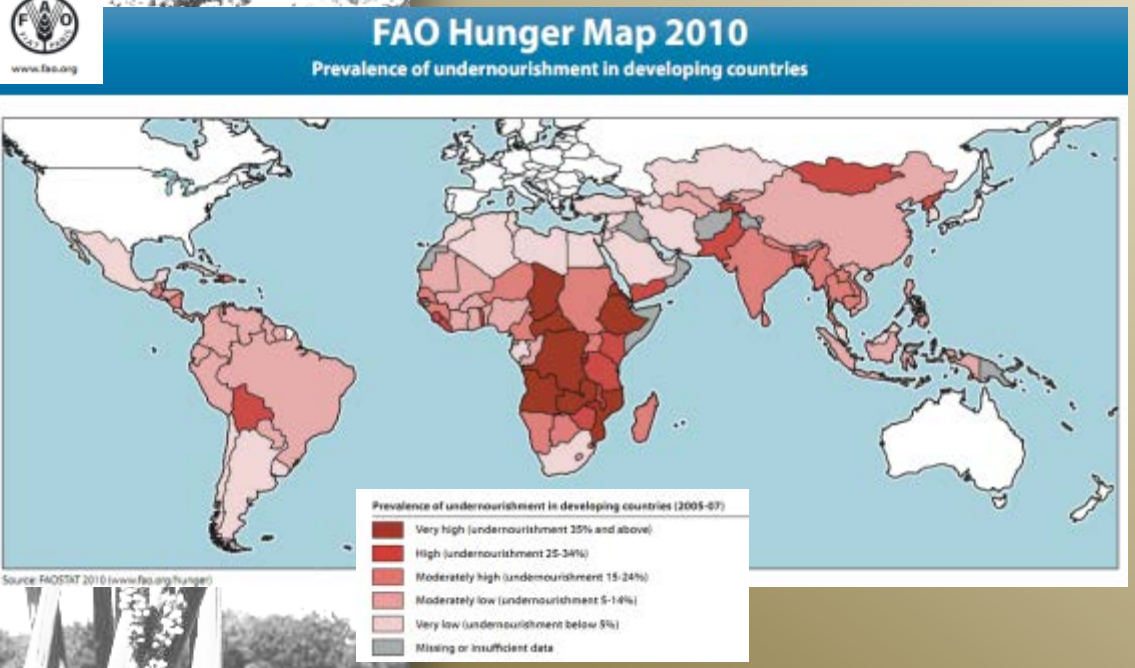
It is urgent to find alternative and sustainable energies

Biofuels, defined as solid, liquid or gas fuels derived from biomass, are today the only direct subsitute for oil on a significant scale particularly in the transport sector

Context

Poorest countries will be lead to grow biofuel crops

- Less arable surfaces available for food production
- Increasing staple food world market prices
  (good for producers, bad for urban consumers)



Instability of the staple food market

Increase of food insecurity

What are the main plants currently used ?

Bio-ethanol 1G

Bio-ethanol 2G

Bio diesel

Sorghum: a multi purposes crop

Biomass sorghum

Sorghum for silage

Grain sorghum

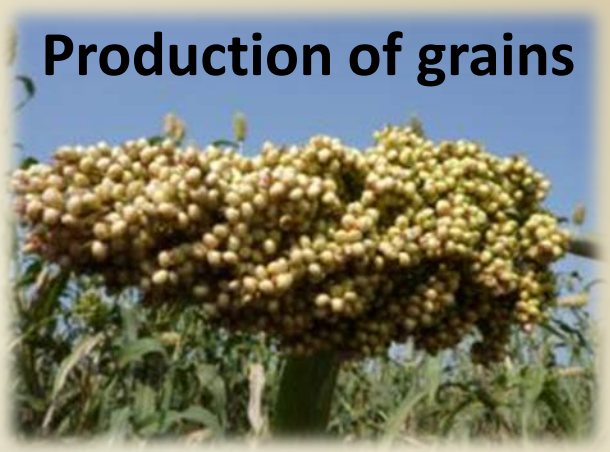
Broom corn sorghum

Sorghum for tinctures

Sweet sorghum

Combination of 2 essential traits:

❶ **Production of grains**



❷ **Accumulation of sugars in the stalks**

Why sorghum for producing ethanol ?

Tropical zone

VS

Propagation
Cuttings seeds

Length of cycle
12-16 months 4-5 months

Water requirements
36 000 m3 8000 m3

Adaptation to dry zones
Irrigation yes

Adaptation to marginal soils
cane < < sorghum

Grain production
0 << up to 6T / ha (2 cycles)

Ethanol production (l ha-1)
6500 5600 (2 cycles)

Uses
Sugar, Fuel Food, Feed, Fuel

Temperate zone

VS

Intrant needs
sorghum < < maize

Water requirement
1/3 less than maize

Nitrogen Use Efficiency
sorghum > > maize

Adaptation to dry environments
sorghum > > maize

Adaptation to marginal soils
sorghum > > maize

Grain
sorghum << maize

Biomass
sorghum ⇔ maize
(25 to 40T DM ha-1)

ADVANTAGE SORGHUM

Hudge potential of improvement and adaptation
Respect of environment
Development of rural zones
Low competition with food crop
Better sustainability of the production system

What sorghum for what biofuel ?

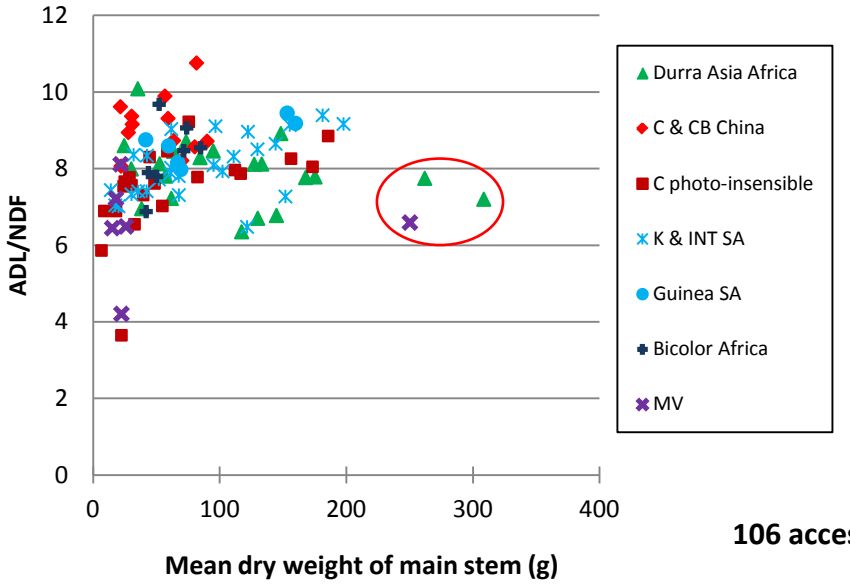
❶ **2nd generation EtOH** or **methane production :** a **biomass sorghum** with the following traits:

- ✓ **High biomass** production (30-40 TDM ha $^{-1}$) which means a plant height > 3.5-4m and a long cycle (4-5 months)
- ✓ good **tolerance to low temperature**
- ✓ a **photosensitivity** adapted to induce late flowering
- ✓ a **good quality** of the raw material which must be poor in lignin (*bmr* trait) to increase **digestibility** of the tissues
- ✓ a good **tolerance to lodging** (antagonistic with *bmr* trait)
- ✓ **tolerance to water deficit** / high water use efficiency

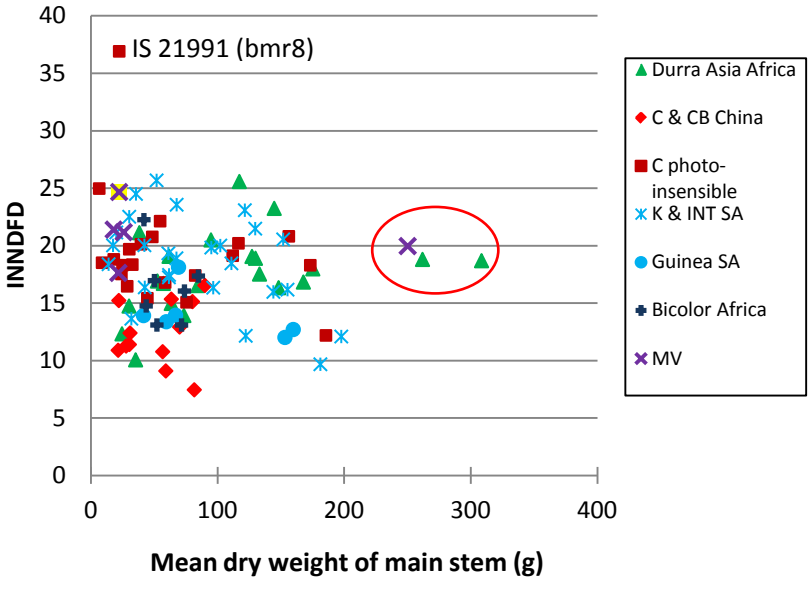
for that purpose, grain production is not essential

What sorghum for what biofuel ?

2nd generation EtOH or methane production : a biomass sorghum



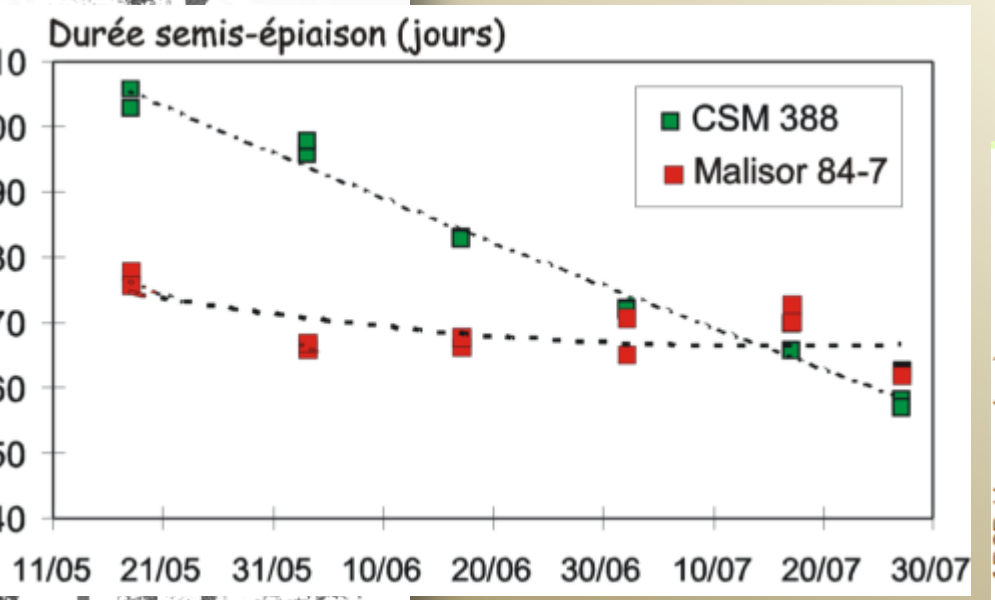
106 accessions

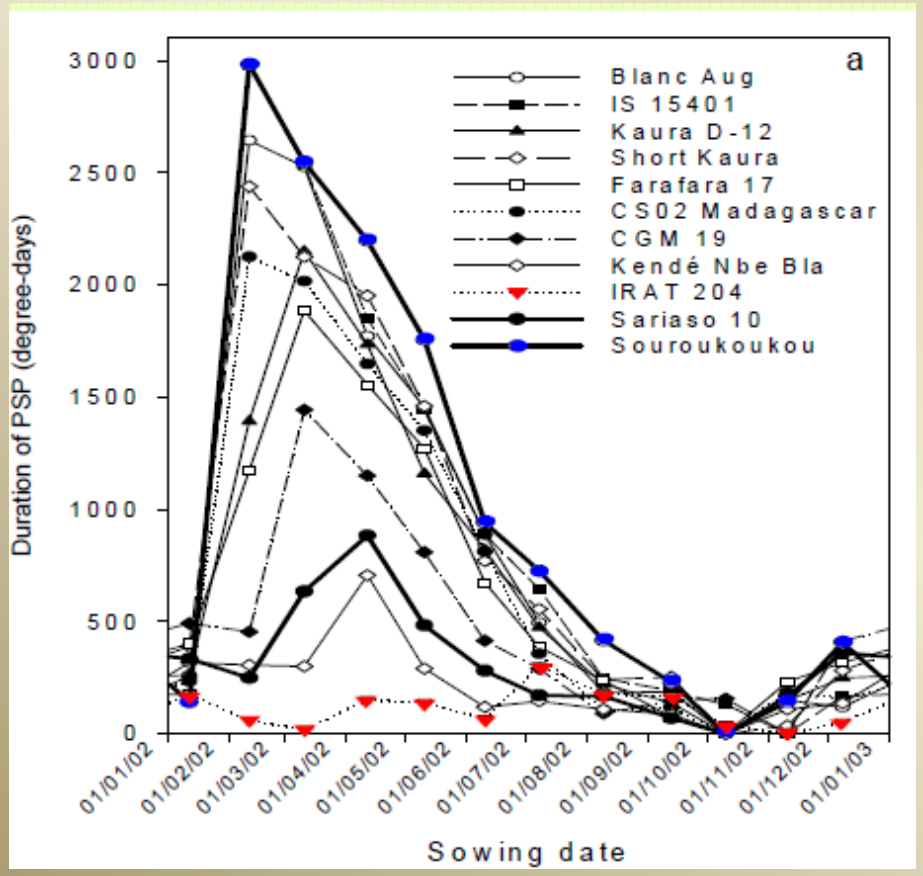


Possible combination of
+ high stalk biomass
+ low lignin content
+ good digestility of fibres

What sorghum for what biofuel ?

Photosensitivity





What sorghum for what biofuel ?

2

1st generation EtOH or **cogeneration :** a **sweet sorghum** with the following traits:

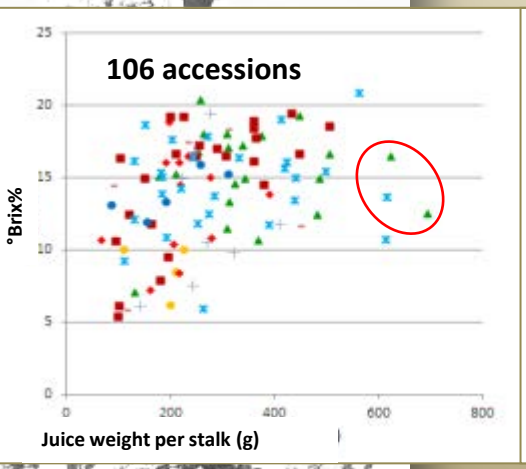
- ✓ **High biomass** production (30-40 TDM ha $^{-1}$) which means a plant height > 3.5-4m
- ✓ high accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose
- ✓ **juicy** stalks
- ✓ high **energetic value of the bagasse** for cogeneration which means more fiber with lignin)
- ✓ a **photosensitivity** adapted
- ✓ adaptation to **marginal soils** (acidity, Al toxicity, P deficiency)
- ✓ **adaptation of crop cycles** (complementary with sugar cane)

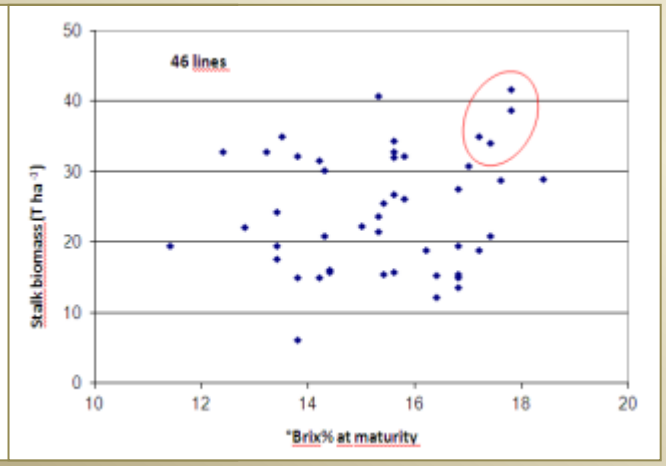
for that purpose, grain production is not wishable

What sorghum for what biofuel ?

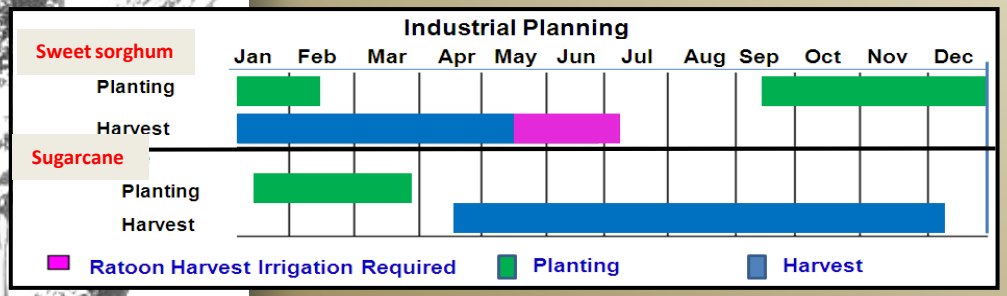
2

1st generation EtOH or cogeneration : a sweet sorghum (Brazil)





gene for tolerance to aluminum toxicity : ***Alt$_{SB}$***



Possible combination of
+ °Brix% with juice
+ °Brix% with stalk biomass
+ Al tolerance
+ complementarity sugar cane cycles (1.8 million ha)

What sorghum for what biofuel ?

3

1st generation EtOH combining **grain** and **fodder**: a sweet sorghum with the following traits:

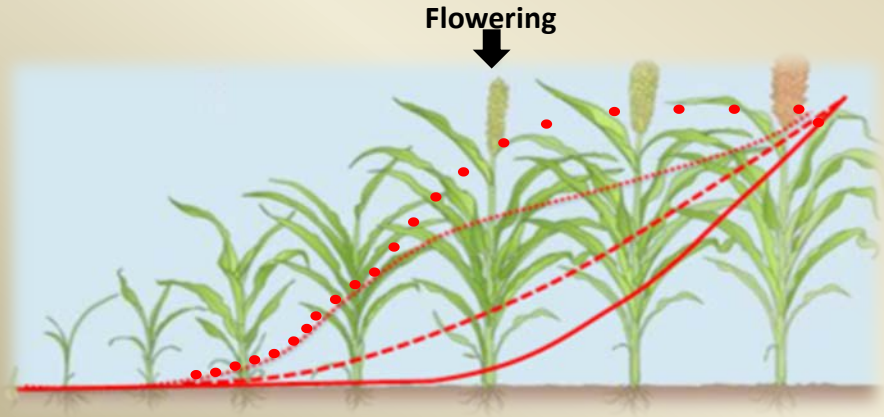
- ✓ **High biomass** production (20-30 TDM ha $^{-1}$) which means a plant height ± 3m and a long cycle (4-5 months)
- ✓ a mean production of **grain** (1.5 to 3 T ha $^{-1}$)
- ✓ high accumulation of **soluble sugars in stalks**, °Brix% of 15 to 20 with 80% of saccharose
- ✓ **juicy** stalks
- ✓ high value of the **bagasse as fodder** which means high digestibility (=*bmr* trait = low lignin content in bagasse)
- ✓ adaptation to **marginal soils** and **rainfall distribution** (stay green, adapted photosensitivity)

for that purpose, grain production is essential

Accumulation of sugar in stalks

Processes of accumulation are not well characterized

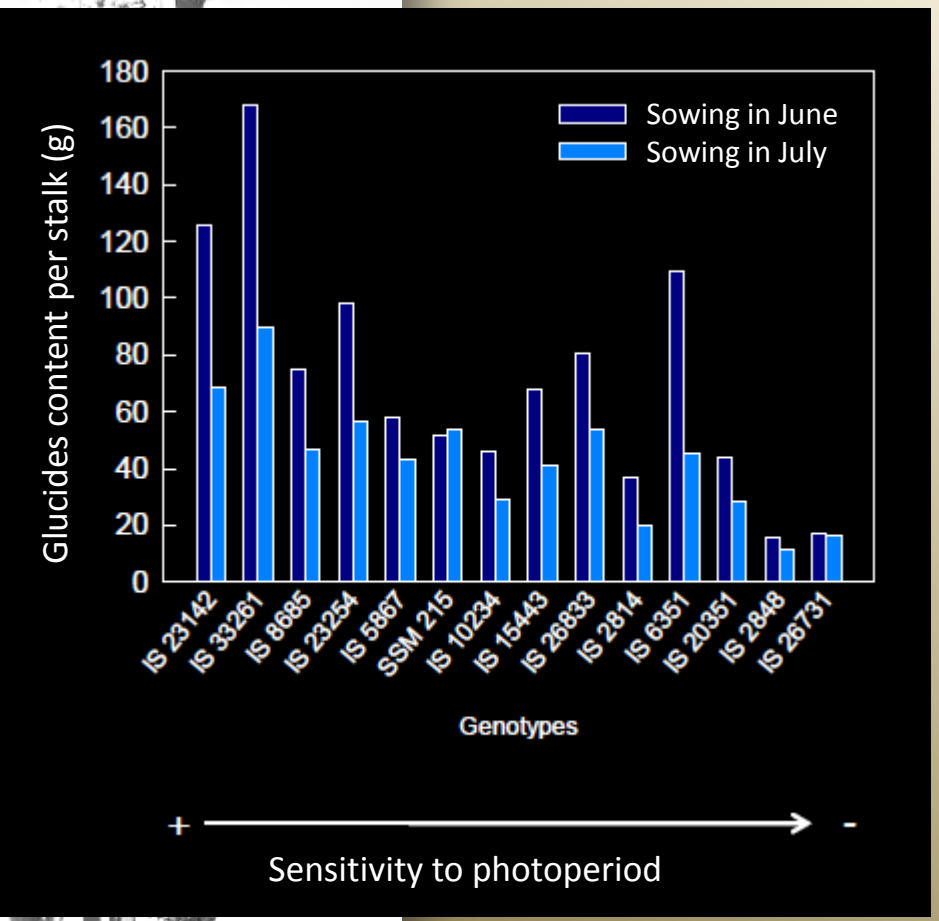
What is the right kinetic of sugar accumulation in stalks ?



Is there a competition between sugar accumulation and grain production ?

Accumulation of sugar in stalks

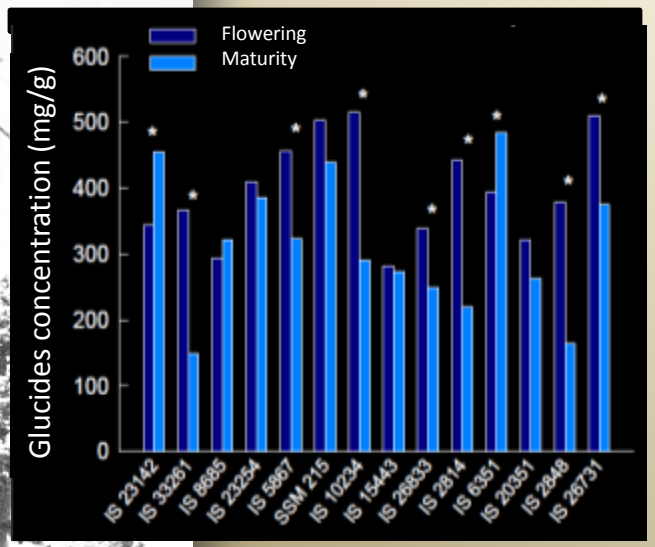
(Source: Gutjahr 2012)

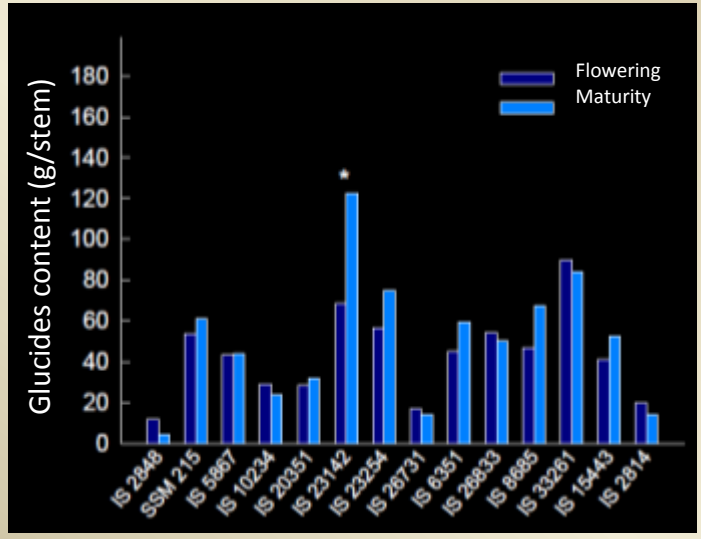


Decrease in yield for late sowing

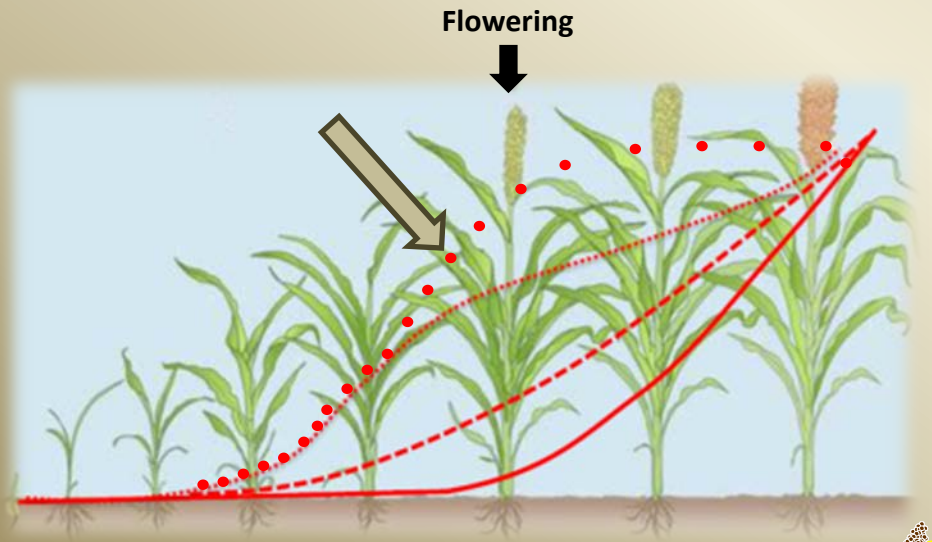
Accumulation of sugar in stalks

(Source: Gutjahr 2012)





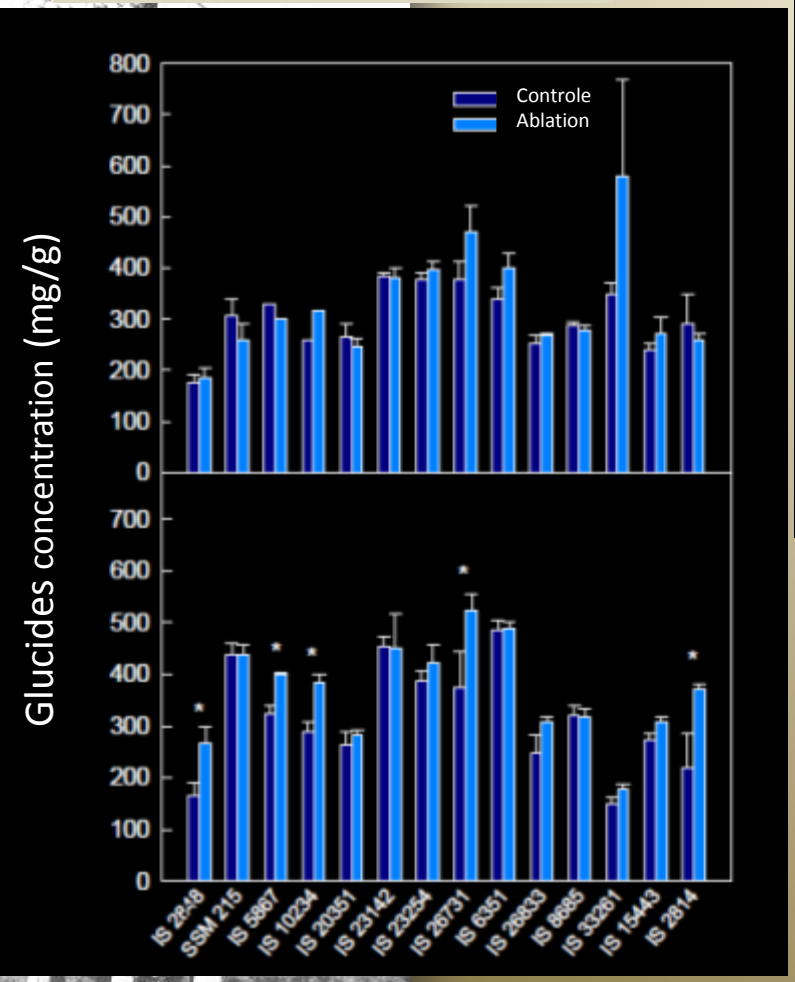
Glucides are accumulated before flowering



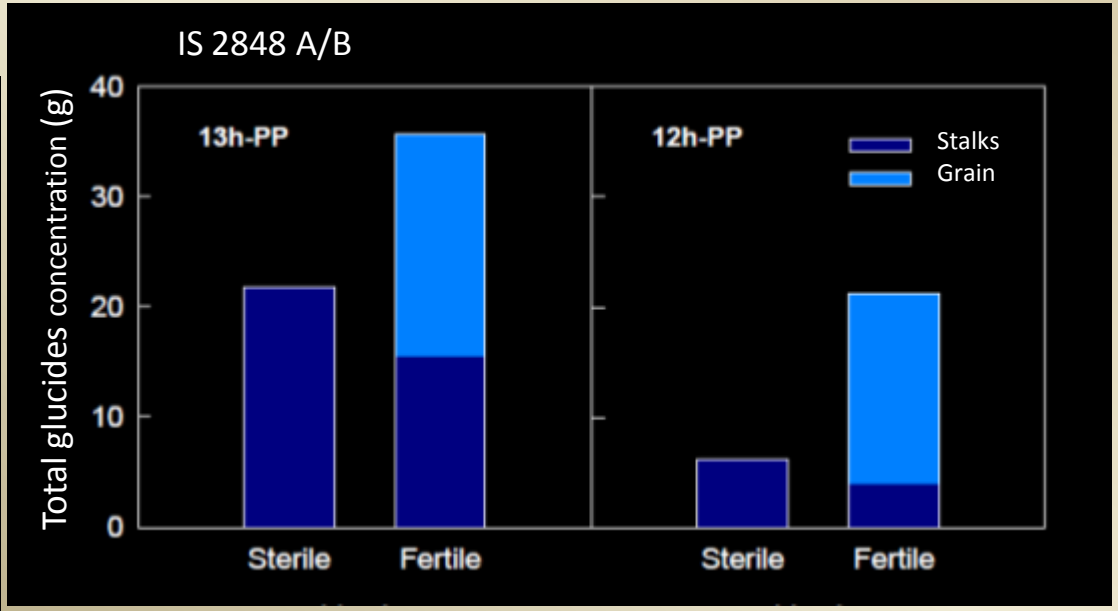
A competition grain/sugar ?

(Source: Gutjahr 2012)

Field experiment



Grennhouse experiment



Ablation of panicule has low influence on sugar accumulation.

Competition between sugar accumulation and grain production seems low
How the excess of glucides is « consumed » when there is no panicule ?

Sweet sorghum: a multiple purpose crop

Food

Feed

Fuel

Fertilizer

Fibers

Bioproducts

...

Project "Biomass for the future" (BFF)

Coordinator:	**INRA - Institut Jean-Pierre Bourgin (IJPB)**
Budget :	**Total = ~ 30 million € for a contribution from the government ~ 10 million €**
Duration	**= 8 years (2013-2020)**
24 partners:	**public institutions (INRA, CIRAD, Armines)** **+ Private sector (from the sectors of breeding, thermoplastics coumpounds, cement, automotive parts, automotive, plant biotechnology etc..)** **+ local authorities**
2 objectives:	**1. Development of local miscanthus (North of France) and sorghum biomass (South) production and valorization chains focused on heat-generation, anaerobic digestion and bio-based construction materials and plastics.** **2. Creation of new varieties and culture systems for miscanthus and fiber sorghum, with improved lignocellulosic biomass yield, reduced environmental footprint and a composition tailored for industrial uses, including second generation biofuels and platform chemicals.**

Thank you

Contact:
serge.braconnier@cirad.fr
www.sweetfuel-project.eu